09/856169
JC08 Rec'd PCT/PTO 04 JUN 2001
/PRTS

LIQUID CRYSTAL DISPLAY SCREEN WITH REINFORCED STRUCTURE

The present invention relates to liquid crystal image display screens, particularly those mounted in image display devices of the so-called "on-board" type, such as used, for example, in aircraft, helicopters, etc.

Liquid crystal image display screens are now well known, and commonly used. They constitute flat screens used to display monochrome or polychrome images. They are mounted in various display devices which are themselves used in various fields, which often impose manufacturing criteria of their own.

Thus, the liquid crystal screens mounted in display devices of the abovementioned "on-board" type are built according to criteria that are more strict than in the case of apparatus intended for the general public. Their manufacture is designed to meet stringent tests, among others vibration tests, by virtue in particular of a reinforcement of their structure.

Figure 1 diagrammatically represents, as a sectional view, a liquid crystal screen 1, whose structure is reinforced in a conventional manner.

The screen 1 comprises a small thickness of liquid crystal 2 enclosed between a first and a second transparent glass plate 3, 4, called a TFT plate 3 and a backplate electrode 4, respectively. The first plate 3 is generally called a "TFT" (standing for "Thin Film Transistor") because this is what bears the network of transistors (not shown), serving to define liquid crystal cells, and to control them under the effect of voltage signals applied with respect to a backplate electrode (not shown), carried by the second plate 4, which is consequently called a backplate electrode 4.

The TFT plate 3 is larger than the backplate electrode

4, the latter being the plate oriented on the side of an observer (not shown) who is looking at the screen 1. These two plates 3, 4 are secured together by a bead of cement 5 formed on the periphery of the backplate electrode 4.

The TFT plate and backplate electrode 3, 4 are borne by a mechanical assembly represented by a wall 6, against which solely the TFT plate is pressed by way of seals 8. Consequently, during vibration trials, the backplate electrode 4 determines a disequilibrium or "imbalance" on the TFT plate 3 that is detrimental to the behaviour of the latter. Since, indeed, the backplate electrode 4 is not held mechanically, it tends to amplify deformations and displacements exhibited by the TFT plate.

Any deformation, even if tiny, of the TFT plate entails a variation (a few tenths of micrometres) in the thickness of the liquid crystal contained between the two plates 3, 4, which variation, even if it is tiny, causes a troublesome disturbance in the displayed image: this disturbance is manifested in the image, for example, as the effects of spots and whiteish wavelets.

The solution generally applied to this well-known problem consists in improving the holding of the TFT plate, by stiffening it with the aid of a reinforcing plate 7 of greater or lesser thickness depending on the reinforcement desired. It should be observed that the reinforcing plate 7 is necessarily transparent and must exhibit certain optical qualities, to allow through light (not shown) intended to be modulated by the screen 1 so as to form the image displayed by this screen.

The reinforcing plate 7 is fixed to the TFT plate 3 by cementing with the aid of a layer 9 of a so-called optical cement; it is fixed on the TFT plate 3, on a

face of the latter opposite the backplate electrode 4. The presence of the reinforcing plate 7 reinforces the mechanical stiffness of the TFT plate, which thus behaves satisfactorily in the vibration tests.

This solution is satisfactory as regards the mechanical stiffness conferred on the TFT plate, but its implementation makes use of a particularly cumbersome process, which demands a large number of successive steps, certain of which are tricky and may give rise to uncertain results. Mention may be made in particular of the steps of preparing the cement, degassing, putting a "primer" on the surfaces to be cemented, depositing cement, cleaning (of overflows in particular), polymerization, etc. All these steps must be performed with great meticulousness so as to avoid degrading the quality of the image, in particular through the presence of bubbles in the cement, dust, etc.

It follows therefrom that the result obtained may be highly variable, and of a quality which is difficult to stabilize without recourse to automation of the process; however, automation in this case is very tricky and therefore so expensive that it cannot be justified other than for mass production. Moreover, on the one hand, the cementing may cause mechanical stresses which may be detrimental to the quality of cementing and also cause deformations and, on the other hand, the cementing may raise problems of differential thermal expansion (glass/cement).

All these stresses may result in cosmetic defects in the image. Let us mention, for example, the appearance of a whiteish lining at the periphery of a black image.

To cope with the various drawbacks and problems raised in the prior art by the fixing of the reinforcing plate to the TFT plate, while retaining the same general structure as that described above with reference to

Figure 1, the invention proposes that the TFT and reinforcing plates be secured by a fixing means other than cement, that is much simpler to use and which therefore does not exhibit the above-explained drawbacks of conventional cementing.

According to the invention, a liquid crystal display screen, comprising a first and a second transparent plate, joined together and between which is contained liquid crystal, the first plate being mechanically reinforced by a transparent third plate, is characterized in that the first and the third plates are secured together by way of an adhesive element comprising at least one double-sided adhesive film.

It is common to use double-sided adhesive films. These films are constructed with the aid of a substance which has the property of adhering strongly to the surfaces onto which it is pressed. They are distributed commercially, for example, by the "3M" company under the name "VHB 3M".

One of the differences between a cement and an adhesive substance such as this is that the latter does not go through any polymerization step, and that, even if it hardens a little over time, it retains much of the flexibility that it had during deployment, unlike cement which tends to harden completely; another advantageous difference as compared with cement is that this adhesive substance exhibits a certain consistency and resistance to crushing.

Double-sided adhesive films are adhesive via each of their two faces, and may therefore be used to join two objects. They are easy to cut, and are available commercially with variable dimensions, ranging, for example, from a few centimetres to several tens of centimetres in width. These adhesive films can be found chiefly in two forms:

- In the first form, the double-sided adhesive film comprises a flexible film serving as support, each face of which is coated with the adhesive substance as defined hereinabove. They are generally presented as rolls, the adhesive film being wound around itself with an isolating film, that is to say a film to which the substance hardly adheres at all.

- In its second form, the double-sided adhesive film is made solely from the mass of adhesive substance; for its storage, it cooperates with an "isolating" film to which it therefore adheres very little, and with the aid of which it is wound around itself so as to be stored, here too, in the form of a roll. Two objects may thus be joined together, each adhering to one of the faces of the same layer of adhesive substance.

Also, the term "double-sided adhesive film" is intended to designate both the case of a double-sided adhesive film made of a supporting film coated with an adhesive substance on each of its faces, and the case of a single layer of adhesive substance with no supporting film, and capable of adhering via each of its faces.

The invention will be better understood and other advantages which it exhibits will become apparent on reading the following description, given by way of non-limiting example, and with reference to the appended figures, among which:

- Figure 1, already described, represents, through a sectional view, a liquid crystal display screen structure of the prior art;

- Figure 2 shows diagrammatically, through a sectional view similar to that of Figure 1, a

first embodiment of a liquid crystal display screen structure in accordance with the invention;

- Figure 3 shows diagrammatically a liquid crystal display screen structure according to the invention, in a variant of the embodiment shown in Figure 2;

- Figure 4 diagrammatically represents a liquid crystal display screen structure in accordance with the invention, according to a second embodiment.

Figure 2 diagrammatically represents a liquid crystal display screen 10 in accordance with the invention, through the same sectional view as that showing in Figure 1 the screen of the known art. The general structure of the screen 10 of the invention is the same as that represented in Figure 1, and the only difference lies in the way in which the TFT and reinforcing plates are secured together.

The screen 1 of the invention therefore comprises a small thickness of liquid crystal 2 enclosed between a TFT plate 3 and a backplate electrode 4, these latter being bonded to one another by a bead of cement 5.

The TFT plate and backplate electrode 3, 4 are borne by a mechanical assembly represented by a wall 6, against which the TFT plate is pressed by way of seals 8. A reinforcing plate 7 is secured to the TFT plate 3 so as to stiffen it.

According to a characteristic of the invention, the TFT plate 3 and the reinforcing plate 7 are fixed to one another with the aid of an adhesive element 11 comprising at least one double-sided adhesive film 12. In the non-limiting example represented in Figure 2, the adhesive element 11 consists of a single double-

sided adhesive film 12. The adhesive element 11 is therefore situated between the two plates 3, 7, in contact with one via one of the adhesive faces and in contact with the other via the other adhesive face.

The adhesive element 11 has a thickness E1 which, in the example of Figure 2, is given by the thickness e1 of the double-sided adhesive film 12; this thickness e1 of the order of, for example, 0.5 mm, is that of the adhesive film 12 after a crushing which it undergoes when it is pressed between the TFT plate 3 and the reinforcing plate 7, so as to adhere to them forcefully. It should be noted that this crushing tends to reduce (relatively moderately) the thickness of the double-sided adhesive film, in proportions liable to vary as a function of its nature; for example, in the case of a double-sided adhesive film of the "acrylic" type, having a thickness at the start of the order of 0.55 mm, its crushing gives it a thickness e1 of the order of 0.5 mm, namely a thickness reduction of the order of 10%.

According to another characteristic of the invention, the adhesive element 11, that is to say the double-sided adhesive film 12, is positioned towards the periphery of the TFT plate 3 and reinforcing plate 7, in such a way as to be placed around a central zone which corresponds to a zone referred to as the "image zone" Zi, defined at the interface of the TFT plate 3 and of the backplate electrode 4. The boundaries of the image zone are set slightly back from the outer edges 18 of the backplate electrode 4 (for example by 2 to 3 mm). The image zone Zi corresponds to the outer boundaries of images which, during operation, are displayed by the screen 1.

The use of double-sided adhesive film, to secure together the reinforcing plate 7 and the TFT plate 3 in

accordance with the invention, allows significant advances:

- on the one hand, it avoids the need, as is the case when using a cement, to employ a process with uncertain results, which is cumbersome to employ and which comprises a large number of tricky steps (which have already been mentioned previously); the time saving afforded by the use of a double-sided adhesive film can be estimated at around 60%, together with better results. Through its flexibility, the double-sided adhesive film also avoids the mechanical stresses prompted by the use of a cement, and avoids the problems of differential thermal expansions which appear over the entire surface in the case of traditional cementing;

- on the other hand, the use of double-sided adhesive film makes it possible to produce a new configuration, which is very difficult or even impossible to obtain with conventional cementing, and which consists in freeing the TFT plate 3 and reinforcing plate 7 of the presence of any cement in the image zone Zi; this has a beneficial consequence in that it avoids impairing the optical qualities of these plates 3, 7 in the particularly sensitive zone, namely the image zone Zi.

As mentioned above, the images are produced from luminous radiation which passes through the TFT and reinforcing plates 3, 7, it is therefore important not to degrade this radiation, otherwise the image will be degraded. With a double-sided adhesive film, it is easy to deposit the latter with a sufficiently precise positioning so that it does not encroach on the image zone, whereas such positioning with a cement is almost

impossible because, in particular, of the fluidity exhibited by the cement.

Trials, in particular vibration trials, have shown excellent and even surprising behaviour of the double-sided adhesive films used in the configuration represented in Figure 2. These trials have been performed with a TFT plate 3 with a thickness E2 of 1.1 mm reinforced by a reinforcing plate 7 with a thickness of 2 mm with the aid of an adhesive element 11 made of a single double-sided adhesive film 12 (of thickness e1 of 0.5 mm), laid at the periphery (width of the adhesive = 5 mm), that is to say around the image zone Zi, as in the example of Figure 2: these trials have shown that a TFT plate such as this behaves in vibration just like with a reinforcing plate of thickness 1.8 mm cemented over its entire surface to the reinforcing plate 7. There is therefore a significant benefit for a very small difference in behaviour, which is easily compensated for if necessary by increasing the thickness E2 of the reinforcing plate.

It should be noted that it may be useful to perform a few trials to determine the most appropriate thickness e1 of the double-sided adhesive film 12, depending in particular on the dimensions and thicknesses of the plates 3, 4, 7. This thickness e1 of a double-sided adhesive film 12 is significant since it conditions the efficacy of the reinforcing plate 7: indeed, a double-sided adhesive film 12 having a thickness e1 which is, for example, too large, may become too flexible, and run the risk of behaving like a term which is elastic to vibrations; if, conversely, this thickness is too small, the reinforcing plate 7 may, under vibration, create shocks when impacting the TFT plate 3.

It is possible, however, to give the adhesive element 11 both the desired degree of flexibility and the

thickness E1 corresponding to the spacing sought between the TFT plate 3 and the reinforcing plate 7. To this end, according to the invention, the adhesive element 11 is made with a composite structure.

Figure 3 represents the adhesive element 11 with composite structure, used in the same configuration as that of Figure 2, that is to say around the image zone Zi. The composite structure of the adhesive element 11 is obtained by associating two double-sided adhesive films 13, 14 with a layer 15 of a different material. Thus, a sandwich-type structure is obtained, with the layer 15 in the central part, trapped between the two double-sided adhesive films 13, 14, of which the outer face of one adheres to the TFT plate 3 and the outer face of the other adheres to the reinforcing plate 7.

By choosing, for the construction of the layer 15, for example a material having a firmer structure than that of the double-sided adhesive films 13, 14, the flexibility of the adhesive element 11 is reduced. The layer 15 constitutes an intermediate substrate which makes it possible to give the adhesive element 11 either a greater thickness E1 or a greater resistance or both of these characteristics. The layer 15 can therefore be formed of a stiffer material than an adhesive film, for example a sheet of plastic, or from glass fibres, or from metal or even from glass, etc. It may, however, be advantageous for the layer 15 to be opaque to light, with a view to reducing any traversal of light through the sides at the level of the junction of the TFT plate 3 and reinforcing plate 7.

In the example shown in Figure 3, the thickness E1 of the adhesive element 11 results from the superposition of the upper double-sided adhesive film 13, of the layer 15 and of the lower double-sided adhesive film 14, having respective thicknesses e1, e2, e3 which are compounded. The double-sided adhesive films 13, 14 may

have different thickness values e1, e3, or identical ones as in the non-limiting example represented where their thickness is, for example, 0.25 mm; the layer 15 can be made of glass fibres with a thickness of the order of 0.30; consequently, the thickness E1 conferred on the adhesive element 11 is of the order of 0.8 mm. Of course, the adhesive element 11 can be formed by the superposition of several sandwiches such as that consisting of the double-sided adhesive films 13, 14 and the layer 15, possibly with different characteristics as to the dimensions and/or nature of the layer 15.

If, for whatever reason, it is desired to stiffen the TFT plate 3 by securing it to the reinforcing plate 7 over a larger surface area, larger than that which results from a peripheral type positioning of the adhesive element 11 as represented in Figures 2 and 3, it is also possible to secure these two plates 3, 7 together via the adhesive element 11 over the entire available surface area; the available surface area is that which corresponds to the facing surfaces of these two plates 3, 7.

Figure 4 represents the TFT plate 3 secured over the entire available surface area to the reinforcing plate 7 by an adhesive element 11. In this case, the adhesive element 11 is formed by a single double-sided adhesive film 16 preferably chosen with good transparency, so as not to affect the optical qualities of the image zone Zi.

It should be noted that, in this case also, the thickness e1 of the double-sided adhesive film 16 is significant, since, if it is too large, it runs the risk, under vibration, of introducing an elastic term and of adversely affecting the efficacy of the reinforcing plate 7. The solution shown in Figure 3 of an adhesive element 11, comprising a sandwich made of

two double-sided films 13, 14 separated by a layer 15 of a different material, can also be used in this version of the invention, on condition that the layer 15 is made of a transparent material, a plastic film or glass for example. Of course, this version of the invention makes it especially necessary to avoid introducing optical defects (bubbles, dust) into the image zone Zi.